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Part 1—What happened to simple useful APC techniques?

Advanced process control (APC) is labor intensive, requiring about one experienced engineer per three major units, a level of effort rarely matched, even in well-run plants. And to do the job right, APC requires people who understand not only control theory but also process engineering, refinery economics and several other disciplines. However, APC experts have been leaving the field at an alarming rate. How can we handle APC efficiently with the current situation? We must find a productive way to use engineers who do not have 20+ years of experience in the field.

Before multivariable predictive control (MVPC) became the industry APC workhorse, we were using a variety of simple techniques, which were discarded not because they were incorrect but because MVPC brought about standardization and less custom coding. Should we try to resurrect certain techniques that are better understood by the non-MVPC experts? I would say that it can be done, although we would have to package them and avoid custom coding.

I have asked my friend and colleague, Greg Martin, to be interviewed about his experience in simple APC techniques. Greg has worked for decades as a control engineer and implemented many such techniques. Recently, as an APC consultant he has also packaged certain techniques for use and ease of maintenance by his clients.

Zak: *Simple APC methods have been abandoned in favor of MVPC implementations. Given the chronic shortage of APC experts, do you think it would be of value to resurrect some of these methods and not always rely on MVPC?*

Greg: Yes! Simplified techniques would be useful not only as stand-alone applications but also in conjunction with MVPCs. My experiences at Setpoint and Profimatics in the '80s and '90s involved multiple applications of simple methods that were easy to understand, design, implement and maintain. The following examples have always received operator approval quickly:

- Pass balancing
- Nonlinear level control
- Lead-lag compensation
- Constraint projections
- Multiple-input, single-output (MISO) predictors
- Simple engineering control calculations: heat duties, ratio and others.

Zak: *I occasionally still see nonlinear level control. Do you see any others being implemented?*

Greg: First, on level control, as we all know the level signal is an integrator of mass balance mismatch. MVPCs are generally not very good with integrator controlled variables (CVs) and their predictions tend to swing. Unless there are overriding considerations I would avoid level control by MVPC in favor of slow averaging linear or nonlinear DCS level controllers.

Other simple APC techniques are nearly gone. I hate to say this, being very much personally involved in the evolution of MVPC, but the loss of the experts to train the younger apprentice control engineers has led to a tendency to use MVPC for all control problems regardless of their nature.

Zak: *Which technique would you resurrect first?*

Greg: Surely heater pass balancing by MVPC is overkill. The pass balancing control algorithm is:

$$\Delta F_i = a(F_i/\Sigma F_i)(T_i - T_{avg})$$

where: T_i = pass outlet temperature for pass i
F_i = pass flow for pass i
ΔF_i = the control move in pass flow i
n = number of passes
$T_{avg} = (\Sigma T_i)/n$
a = tuning parameter of about 0.1

This algorithm has the convenient feature that the sum of the moves equals zero:

$$\Sigma \Delta F_i = 0$$

i.e., pass balancing is carried out without disrupting the total flow through the heater.

I have seen this controller in action many times. The pass outlet temperatures converge quickly to approximately equal values.

Zak: *Would you also consider constraint projection or leave it for MVPC?*

Greg: Constraint control using projections applies to a single-input, multiple-output problem where there is one manipulated variable and several constraints. If that is the entire problem with no other complication then it is easier to handle without MVPC. I would leave the decision to the APC engineer on this one. HP

Part 2 will cover a simple SISO model predictive controller.

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